and magnitude of the signal-to-noise ratio maximum value may be usefully predictable from the touch signal profile.

[0073] Therefore, in the presence of touch induced noise, a preferred time for making the touch location measurement is not entirely dependent on making the location measurement at the earliest point the touch signal rises above a particular amplitude, as in conventional methods. Touch induced noise may decrease as the signal level increases through some initial portion of the touch signal profile. Thus a preferred time to make the touch location measurement may depend upon recognizing an improved signal-to-noise ratio due to diminished noise amplitude as well as increased touch signal amplitude. The preferred time to make the touch location measurement may be somewhat delayed with respect to the conventional method of acquiring a location measurement at the earliest time the signal rises above a certain level. However, in many applications, the slight delay in acquiring touch location information is undetectable by the user. Further, the enhanced accuracy achieved by making the touch location measurement at a preferred time of lowest noise outweighs any slight delay in acquiring the location measurement. The present invention provides a method and system that advantageously determines a preferred time for making the touch location measurement in the presence of touch induced errors and other error sources.

[0074] Two touch signals of different strengths may be considered to have the same profile if they have the same duration, and if the amplitude of one is equal to a constant scalar multiple of the amplitude of the other at each point. According to the methods of the present invention, a preferred time for touch location measurement represents a point of relatively small dynamic touch induced error. Further, the preferred time for touch location measurement tends to be characterized by a feature of a touch signal shape that is associated with a particular time within a given touch signal profile, regardless of the touch signal strength. Methods of the present invention may be contrasted to prior art methods that use fixed amplitude thresholds. Such conventional methods calculate touch location from data taken at variable times within a given touch signal profile. By conventional methods, the touch locations of progressively stronger touches, with the same touch signal profiles, are calculated from data taken at progressively earlier points.

[0075] According to the present invention, touch location may be calculated from data gathered at a preferred time within the touch signal profile. Accurate determination of the preferred time for touch location measurement by this method may entail two decisions: 1) a decision that a touch event has begun, and 2) a decision that a preferred time for touch location measurement has occurred. These decisions may be made in either order, or together. Both decisions, however, may be responsive to some range of the recent history of the touch signal, as well as to the signal value at the time of touch location measurement. Thus, a touch condition may first be determined, as by the touch signal exceeding a predetermined threshold. In contrast to conventional methods, when the touch signal exceeds a predetermined threshold, a touch condition is detected, however a touch location measurement is not performed. A location point may be established when a preferred time for making a touch location measurement condition is satisfied. Alternatively, the presence of a preferred time for location measurement condition may be established first, and then the force history examined. If the force history shows a smooth rise of sufficient magnitude from a quiescent level, a touch condition may be considered to exist and the preferred time for location measurement is taken at the point the preferred time condition occurs.

[0076] A preferred time for touch location measurement may be determined from a touch signal acquired by summing the output of all the sensor signals. However, in some applications, it may be advantageous to determine a preferred time from one sensor signal or from various combinations of sensor signals. In addition, a different preferred time for touch location measurement may be determined for each sensor signal. Touch location accuracy may also be improved by interpolating a touch signal or sensor signal to find a signal value for location measurement between touch signal sample values.

[0077] It should be noted that the threshold values or force signal history used to signify a touch input need bear no relationship to the thresholds used in conventional methods to determine touch location. As such, the present invention can be used to determine the location of relatively small magnitude touch inputs that would not have been registered using conventional methods for lack of reaching a predetermined value.

[0078] According to the present invention, a method for determining a touch location involves identifying a feature of a touch signal shape correlated to a period of relatively low touch signal noise. The detection of the feature in the touch signal profile corresponds to a preferred time for making a touch signal measurement to determine the touch location. In one example, the feature of the touch signal shape used to initiate a touch location measurement is the slope of the touch signal. When the slope of the touch signal is equal to a predetermined value, the touch location measurement may be made. In another example, a relative slope may be employed as the touch signal shape used to trigger a touch location measurement. The relative slope may be calculated as the touch signal slope at a particular time divided by the magnitude of the touch signal at the particular time.

[0079] The flowcharts of FIGS. **6A-6E** illustrate, in broad and general terms, various methods of the present invention. The method of the invention illustrated conceptually in the flowchart of **FIG. 6A** involves acquiring a touch signal corresponding to a touch on the touch screen **605**. A first occurrence of a touch signal shape in the touch signal is detected **610**. Touch location is determined using touch signal information obtained in response to detecting the touch signal shape **615**.

[0080] In accordance with another method of the invention, illustrated in **FIG. 6B, a** touch signal shape is associated with a level of touch signal error **620**. The level of touch signal error may represent a relatively low level of error in comparison to a maximum touch signal error. Identification of the touch signal shape associated with the level of touch signal error may be calculated from known properties of the touch screen design, or may be determined by other means. A touch signal corresponding to a touch on a touch screen is acquired **625** and a first occurrence of the touch signal shape in the touch signal is detected **630**. Touch location is determined using touch signal information obtained in response to detecting the touch signal shape **635**.